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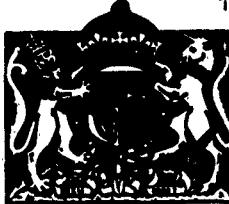
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**MINISTRY OF SUPPLY**

**AEROPLANE AND ARMAMENT  
EXPERIMENTAL ESTABLISHMENT**

**BOSCOMBE DOWN**

SHACKLETON M.R. MK.2 VV.126  
(4 X GRIFFON 57)

ASSESSMENT OF DIRECTIONAL WANDER ON THE PROTOTYPE  
M.R. MK.2 AIRCRAFT

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# REPORT

15th Part of Report No. AAEE/866/1

AEROPLANE AND ARMAMENT EXPERIMENTAL ESTABLISHMENT  
BOSCOMBE DOWN

18 JAN 1954

Shackleton MR. Mk. 2 VW.126  
(4 x Griffon 57)

Assessment of directional wander on the prototype  
MR. Mk.2 aircraft

A. & A.E.E. Ref: AAEE/5717,u/1/MB.  
M. O. S. Ref: SB.67151/01/R.D.L.2(a)  
Period of Test : August - September, 1952.

### Progress of issue of Report

Report No.	Title
10th Part AAEE/866/1	WG.530 B.17 Mark 6 turret. Check of redesigned gun fire interruption drum.
11th - do -	WG.530 Engine and oil cooling trials under near tropical conditions.
12th - do -	WG.530 Climb performance.
13th - do -	WG.530 Carriage and release of T.1946 (B.R.) Directional sonobuoy carrier on Avro 100/1000 lb. Mk.1 B/AN carrier.
14th - do -	WG.532 Normal accelerations during certain anti-submarine attacks.

### Summary

A brief assessment of the directional wander characteristics was made on VW.126, the prototype Shackleton M.R. Mk.2.

This showed that the short period directional oscillation and the general wander previously found on the M.R. Mk.1 variant were still present.

However, in the comparable operating conditions tested, that is, with normal manual control in calm to moderate air turbulence conditions the magnitude of the wander was considerably less than on the M.R. Mk.1 aircraft. The total change of heading liable to occur within a period of 30 seconds was about 2°.

This Report is issued with the authority of



Air Commodore,  
Commanding, A. & A.E.E.

/Introduction.....

### 1. Introduction

During the course of handling trials on WV.126, the prototype Shackleton M.R. Mk.2 aircraft, the opportunity was taken of making an assessment of the directional wander. The assessment was similar to that made on VP.263, an M.R. Mk.1 aircraft (see 33rd part of Report No. AAEE/866).

### 2. Condition of aircraft relevant to tests

2.1. General. The aircraft was as described in the 2nd part of this Report but certain details are repeated herein for ease of reference.

2.2. Fuselage. The external shape of the fuselage differed from that of the M.R. Mk.1 variant as follows:-

(a) The nose was of an entirely different form and extended the fuselage, forward of the pilot's windscreens, by approximately 4 feet.

(b). The radar scanner fairing or "radome" was not mounted under the nose but was situated in a ventral position with its leading edge approximately 7 feet aft of the mainplane trailing edge.

(c) The rear end of the fuselage aft of the tailplane was lengthened by some 6 feet and formed a faired tail cone.

Figure 1 shows a comparison, in side elevation, between M.R. Mk.1 and M.R. Mk. 2 aircraft.

2.3. Rudder trimmers. The pilot operated trim tabs had a range from 12 divisions 'turn port' to 12 divisions 'turn starboard'.

With the cockpit indicator reading zero the port tab "toed out" approximately  $2^{\circ}$  to port and the starboard tab  $4\frac{1}{2}^{\circ}$  to starboard.

The backlash in the trimmer system was considerable, being of the order of  $\pm 1^{\circ}$ .

2.4. Instrumentation. The instrumentation was very similar to that used in VP.263 (see 33rd part of Report No. AAEE/866). A Hussonot A.20 recorder was used to obtain continuous records of aircraft heading, normal acceleration and rudder angle (not used for this investigation). These quantities were measured respectively by a German Mk.1B gyroscope, a Smith-Barnes accelerometer and Desynn type transmitters.

The recorder was set to give a nominal trace length of 1 millimetre per second. Bench calibrations showed that transverse trace movements of 1 cm. corresponded to changes of  $4.8^{\circ}$  in heading and  $0.83^{\circ}g$  in normal acceleration.

Movement of the two traces towards the top of the paper implied respectively a change of heading to port, and a positive increment in normal acceleration.

The precession of the gyroscope was assessed as causing an apparent change of heading of  $30^{\circ}$  to port per hour in calm air conditions and  $45^{\circ}$  per hour in air conditions of very heavy turbulence.

### 3. Scope of tests

Measurements of aircraft heading, normal acceleration and rudder angle were obtained on the continuous trace recorder with the pilot manipulating the flying controls as follows:-

(a) Using all controls normally and attempting to maintain laterally level flight on a constant heading.

/(b).....

(b) With the rudder pedals left free and attempting to maintain laterally level flight on a constant heading by use of the aileron control, and

(c) With the rudder pedals "fixed", that is with feet pressed hard on the pedals in an attempt to prevent rudder movement. The aileron control was used as in (b).

In each case, the pilot first trimmed the aircraft as accurately as possible about all three axes.

All the tests were made, with flaps, undercarriage and radome retracted, at an altitude of approximately 2,000 feet with engine settings of 1600 r.p.m., +4 lb/sq.in. boost. These operating conditions gave indicated airspeeds of between 155 and 165 knots I.A.S. and were considered typical of those under which the aircraft would be operated for long periods in its maritime reconnaissance role.

The trials were necessarily brief, and only air conditions of negligible and of mild to moderate turbulence were encountered.

The automatic pilot was not available for use on these trials.

#### 4. Results of tests

4.1. General. The results are presented in a similar manner to that of the report on VP.263, an M.R. Mk.1 aircraft, and no attempt is made to account for any difference in behaviour between the two variants. A later report will be issued on the subject of the possible reasons for the directional wander.

All the records obtained have been reproduced photographically in figures 2 to 4; they have been reduced to one half of their original size, and as a result are rather too small for further analysis by the reader. The originals are retained at this Establishment and can be seen on request.

Scales to indicate the aircraft heading have been included at the beginning and end of each record.

The methods adopted for analysis of the records and assessment of the degree of air turbulence were those described in the 33rd part of the Report No. M.R.E/366. Some information is, however, repeated for ease of reference.

4.2. Five-second per cycle oscillation. The five-second per cycle oscillation which had been noted previously during tests on the M.R. Mk.1 variant, was again present. A summary of the changes of heading due to this oscillation under varying conditions of control is given in Table 1. Those results obtained with the pilot controlling the aircraft normally are directly comparable with the results obtained on VP.263, an M.R. Mk.1 aircraft.

The records were grouped together according to the degree of air turbulence and the type of control.

The mean value of the double amplitude of oscillation\* was assessed for each 30 second period and an average was then taken of all such values obtained in the repeat tests in similar air conditions.

Thus for each degree of air turbulence a value was obtained which has been called the "average mean double amplitude".

In general, changing the conditions of the rudder control had little effect on the mean double amplitude of oscillation.

4.4. General wander. As found in the tests of the M.R. Mk.1 variant, there was, superimposed on the five-second per cycle (or short period) oscillation, a general wander.

/In.....

\* The double amplitude is the total change of heading during one cycle.

In the conditions of air turbulence encountered during these present tests it was not possible to ascribe any periodicity to this wander.

Reference to Table 1 shows that there was little difference in the magnitude of this wander between tests when the pilot operated the rudder control normally and when he left the rudders "free".

However, there was an appreciable increase when the rudders were held "fixed".

#### 5. Discussion of results

The results of tests made with the rudder control operated normally by the pilot are directly comparable with those given in Table 1 of the 33rd part of Report No. AERE/866.

Such a comparison shows that while the magnitude of the short period oscillation is of approximately the same order the general wander is considerably less than on the M.R. Mk.1 aircraft. The general wander is probably as small as is likely to be obtained on an aircraft flown under manual control.

#### 6. Conclusions

The tests showed that the short period directional oscillation and the general wander previously found on the M.R. Mk.1 variant were still present on the prototype Shackleton M.R. Mk.2 aircraft, VW.126.

In comparable operating conditions, that is, with normal manual control in negligible or in mild to moderate air turbulence, the magnitude of the short period oscillation was of about the same order whilst that of the general wander was considerably less than on the M.R. Mk.1 aircraft. The total change of heading liable to occur within a period of 30 seconds was about 2°.

#### 7. Further developments

A later part of this report will be issued on the subject of the possible causes of the directional wander on the Shackleton as a type.

#### Circulation List

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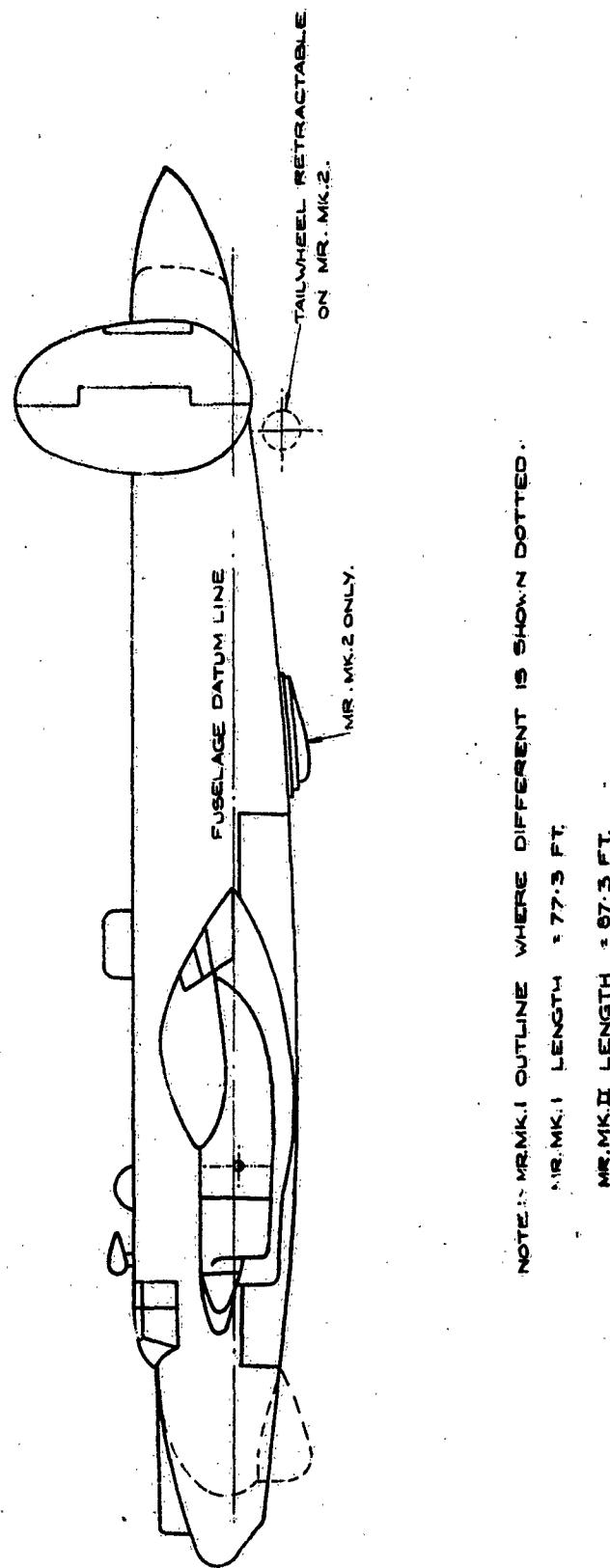
SUMMARY OF RESULTS FROM HUSSEYNT RECORDER

(Values given to the nearest  $\frac{1}{4}^{\circ}$ )

TABLE 1

Fig. No.	Record Ref. No.	Number of 30 sec. periods examined	Degree of air turbulence	Rudder control	Change of heading due only to 5 second per cycle oscillation (degrees)		Change of heading over 30 second period (degrees) (mean for several hours)		Excluding 5 second per cycle oscillation per cycle oscillation
					Mean during whole record	Maximum during whole record	Including 5 second per cycle oscillation	Excluding 5 second per cycle oscillation	
A	10	Negligible	Normal		1	$1\frac{1}{2}$	$2\frac{1}{2}$	$1\frac{1}{2}$	
B	13	Negligible to Mild			$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
C	13	Negligible to Mild			1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
D	13	Mild to moderate			1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
E	12	Mild to moderate			1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
F	13	Mild to moderate			1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
G	13	Mild to moderate			1	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
H	20	Mild to moderate			1	$1\frac{1}{2}$	$2$	$1\frac{1}{2}$	
I	13	Negligible to mild	"Free"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
J	13	Negligible to mild	"Free"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
K	13	Negligible to mild	"Free"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
L	15	Mild to moderate	"Free"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
M	13	Mild to moderate	"Free"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
N	9	Mild to moderate	"Free"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
O	13	Negligible to mild	"Fixed"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
P	13	Negligible to mild	"Fixed"		$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{1}{2}$	
Q	14	Mild to moderate	"Fixed"		$1\frac{1}{2}$	$2\frac{3}{4}$	$2\frac{3}{4}$	$2\frac{3}{4}$	
R	18	Mild to moderate	"Fixed"		$1\frac{1}{2}$	$3$	$3$	$3$	
S	14	Mild to moderate	"Fixed"		$1\frac{1}{2}$	$3\frac{1}{4}$	$3\frac{1}{4}$	$3\frac{1}{4}$	
T	16	Mild to moderate	"Fixed"		$1\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{1}{2}$	

FIG. I



NOTE : MR.MK.I OUTLINE WHERE DIFFERENT IS SHOWN DOTTED.

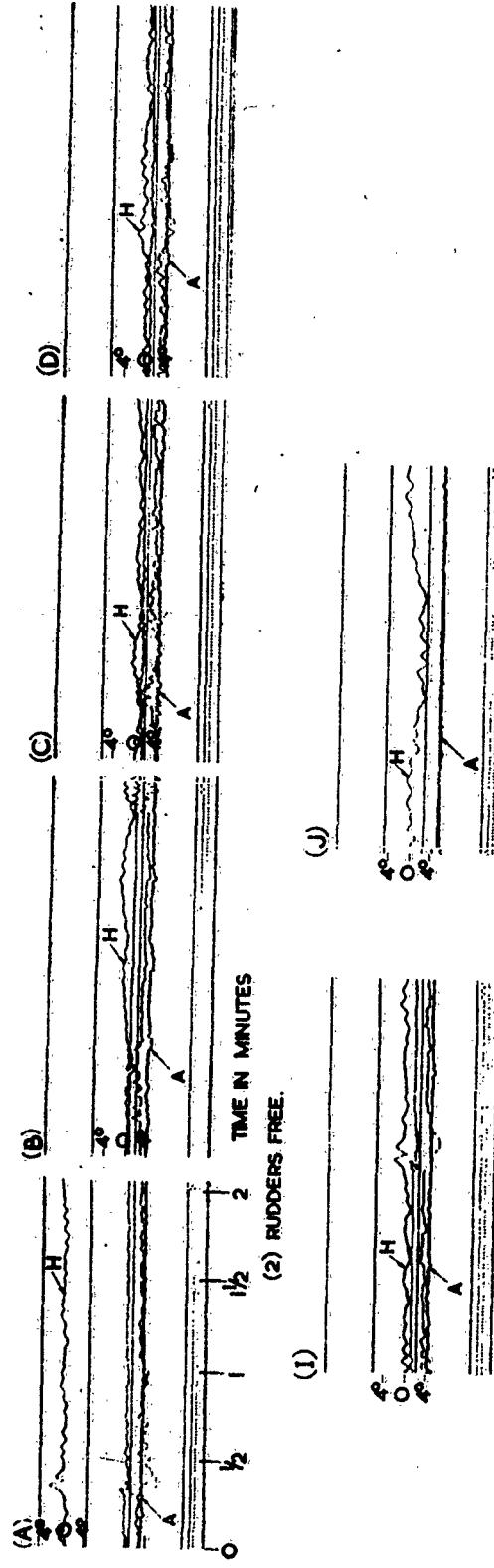
MR. MK. I LENGTH = 77.3 FT.

MR. MK. II LENGTH = 67.3 FT.

COMPARISON BETWEEN SHACKLETON MR. MK.I AND  
MR. MK.2

CRUISING FLIGHT AT 2-3000FT. AT 155-165 KNOTS, 1500R.P.M. 44 LB./SQIN. BOOST.  
NEGIGIBLE TO MILD TURBULENCE.

(1) PILOT CONTROLLING NORMALLY.



(1) PILOT CONTROLLING NORMALLY.

(2) RUDDERS FREE.

(3) RUDDERS FIXED.

(4) RUDDERS FREE.

(5) RUDDERS FREE.

(6) RUDDERS FREE.

(7) RUDDERS FREE.

(8) RUDDERS FREE.

(9) RUDDERS FREE.

(10) RUDDERS FREE.

(11) RUDDERS FREE.

(12) RUDDERS FREE.

(13) RUDDERS FREE.

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(29) RUDDERS FREE.

(30) RUDDERS FREE.

(31) RUDDERS FREE.

FIG.2.

AIAE NEG. NO. 16008.

HUSSENOT. RECORDS OF AIRCRAFT HEADING AND NORMAL ACCELERATION.

A — INDICATES THE CURVE OF  
H — AIRCRAFT HEADING.

CRUISING FLIGHT AT 2-3000FT. AT 155-165KNOTS. 1600 R.P.M. + 4LB./SQ. IN. BOOST.  
MILD TO MODERATE TURBULENCE.

(1) PILOT CONTROLLING. NORMALLY.

(E) \_\_\_\_\_

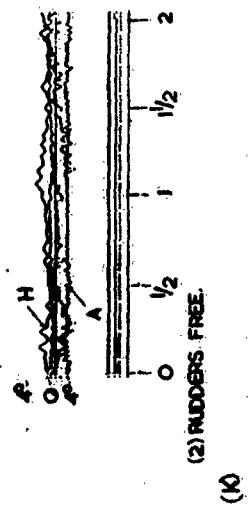
(F) \_\_\_\_\_



(2) RUDDERS FREE.

(K) \_\_\_\_\_

(L) \_\_\_\_\_



(3) RUDDERS FIXED.

(Q) \_\_\_\_\_

(R) \_\_\_\_\_



A.S.A.E. REG. NO. 16908.

FIG. 3.

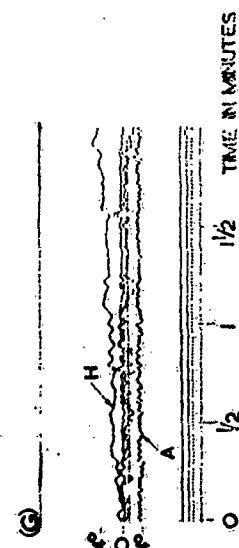
**INDICATES THE CURVE OF  
ACRAFT NORMAL  
ACCELERATION.**

**H — AIRCRAFT HEADING.**

• HUSSEINOT RECORDS OF AIRCRAFT HEADING AND NORMAL ACCELERATION.

CRUISING FLIGHT AT 2-3000FT. AT 155-165KNOTS, 1600R.P.M. + 4LB./SQIN BOOST.  
MLD TO MODERATE TURBULENCE.

(1) PILOT CONTROLLING NORMALLY.



(2) RUDDERS FREE.



(3) RUDDERS FIXED.

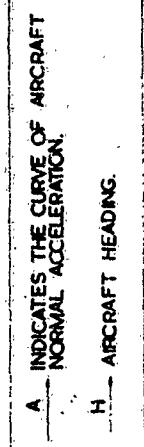
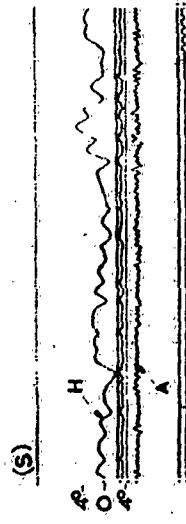


FIG 4.

A.A.E.E. NEG. NO. 10008.

HUSSENOT RECORDS OF AIRCRAFT HEADING AND NORMAL ACCELERATION.



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